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PERSISTENCE OF ANTARCTIC POLAR STRATOSPHERIC CLOUDS

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It has recently been recognized that Polar Stratospheric Clouds (PSCs) may have multiple stages of growth (Poole and McCormick, 1988a): the preliminary stage consisting of binary HNO_3-H_2O particles (Type I) at temperatures slightly above the frost point (Toon et al., 1986, and Crutzen and Arnold, 1986) and another stage composed predominantly of ice (Type II) below the frost point. Crutzen and Arnold (1986), McElroy et al. (1986), and Toon et al. (1986) have suggested that the formation of PSC particles may effectively immobilize the gaseous NO_x reservoir and allow for the catalytic removal of ozone in the early Antarctic spring. In light of these developments, the persistence of PSCs observed by the Stratospheric Aerosol Measurement (SAM) II satellite sensor over a 9-year period is compared and contrasted. Details of the SAM II experiment are contained in McCormick et al. (1979) and McCormick et al. (1982). Histograms of the SAM II 1.0-μm extinction ratio data (aerosol extinction normalized by the molecular extinction) at an altitude of 18 km in the Antarctic have been generated for three 10-day periods in the month of September and are presented in Figures 1-3. Statistics for eight different years (1979-1982 and 1984-1987) are shown in separate panels for each figure.

Examination of Figure 1 (September 1-10) shows a wide range of extinction ratio values in each panel. For the most part, minimum values approach 0.25 whereas maximum values for each case vary considerably over the range from 10-100. It is not apparent from the shapes of the histograms that a preferred mode exists, but the plots do show a tendency for more larger values to be present in the later 4 winters than in the earlier set. Based on the inverse temperature-extinction relationship reported by McCormick et al. (1982), the higher extinction ratio values sighted should be accompanied by colder temperatures. Associated temperature data, obtained from the NMC temperature analysis and not shown here, do not exhibit distinctly colder conditions in the later 4 years. This inconsistency may be partially explained by uncertainties in the NMC analysis or by real changes in the environmental concentration of water vapor or nitric acid vapor as the result of particle sedimentation. The second 10-day period, September 11-20, is presented in Figure 2. It shows that the mode of the distribution has shifted toward smaller extinction ratios, which continues into the last 10-day period displayed in Figure 3 (September 21-30). These very low values are likely due to particle evaporation and the vertical redistribution of the aerosol layer by subsidence and sedimentation that takes place over the course of winter. Usually by the end of September, the lower stratosphere above about 17 km is "cleansed" of smaller particles present prior to PSC formation. Unlike any of the other years, PSCs (values >10) are clearly evident in the 1987 data set throughout September and into the first week of October. Although data are not presented in this abstract on PSCs at other altitudes, clouds tend to persist slightly longer at lower heights (16 km) and also disappear earlier at higher altitudes (20 km). In fact, extinction ratio values >10 were observed for the first time at 16 km throughout September in 1985 and again in 1987. Further, PSCs persisted through mid-September 1987 for the first time at 20 km.

Since the SAM II system is a solar occultation experiment, observations are limited to the edge of the polar night and no measurements are made deep within the vortex where temperatures could be colder. For this reason, we make use of the NMC global gridded fields and the known temperature-extinction relationship to infer additional information on the occurrence and areal coverage of PSCs. Calculations of the daily areal coverage of the 195 K isotherm will be presented for this same period of data. This contour level lies in the range of the predicted temperature for onset of the Type I particle enhancement mode at 50 mb (Poole and McCormick, 1988b) and should indicate approximately when formation of the binary HNO_3-H_2O particles begins.

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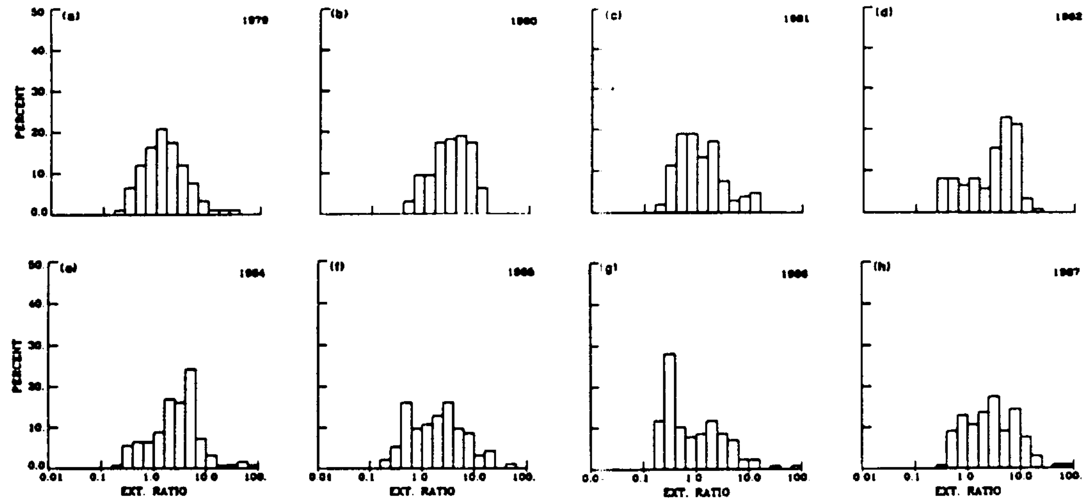

Fig. 1. Histograms displaying the probability distribution of the SAM II 1.0 µm aerosol extinction ratio data in the Antarctic region for a 10-day period, September 1-10. Each panel represents a separate year: (a) 1979, (b) 1980, (c) 1981, (d) 1982, (e) 1984, (f) 1985, (g) 1986, (h) 1987.

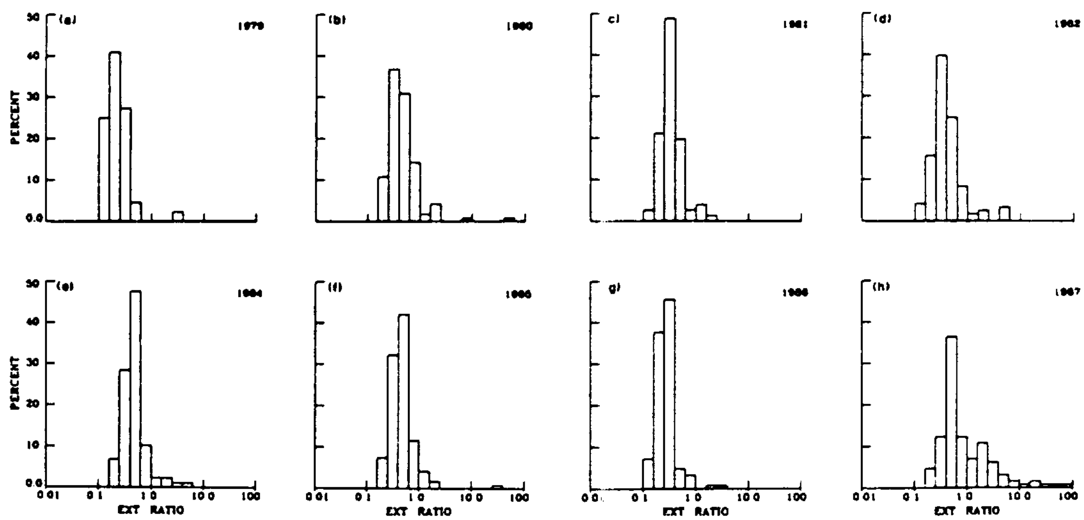

Fig. 2. Same as Fig. 1 except that the 10-day period covers September 11-20.

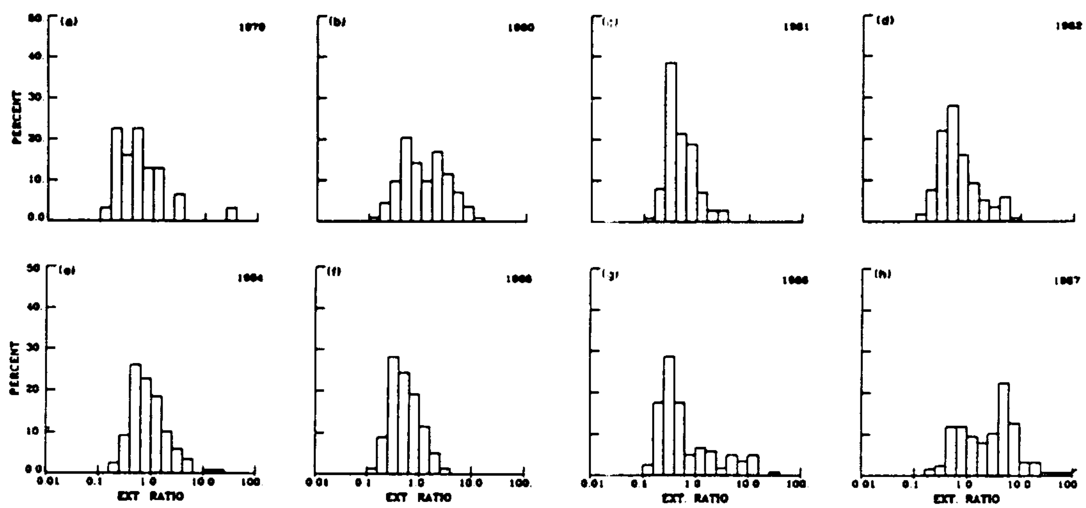

Fig. 3. Same as Fig. 1 except that the 10-day period covers September 21-30.